Orbits About Asteroid 4179 Toutatis

D.J. Scheeres, S.J. Ostro (JPL/Caltech), R.S. Hudson (Wash. State U)

Using a radar-based model for the shape and spin state of Toutatis, (Hudson and Ostro, submitted for publication), we have estimated the gravity field of this very irregularly shaped, non-principal-axis (NPA) rotator and have begun to explore the dynamics of particles close to it.

Our gravity-field calculations (Werner, CM 59, 1994) assume a constant density of 2.5 g/cm^3. Because of the NPA rotation, the kinematic accelerations acting on a surface particle. vary periodically with time; these variations are 2 to 3 orders of magnitude weaker than the acceleration due to gravity alone, but presumably contribute to dissipation of the asteroid's rotational kinetic energy and to long-term evolution of the spin state. The dynamic slope over the surface is quite shallow, much less than 33 degrees over the majority of the surface, which seems consistent with an equilibrated regolith due to the time-periodic forcing on the body.

Due to Toutatis' large nutation angle ($\sim$ SO^{0}), both the inclination and node (measured with respect to the invariable plane, which contains the center of mass and is normal to the angular momentum vector) of a close orbit will evolve with large quasi-periodic variations; in some instances the inclination variation can have an amplitude > 90°. Nonetheless, both stable and unstable periodic orbits exist (for specific initial conditions) as closed orbits in the asteroid-fixed frame.

A particle ejected from the surface with a body-fixed speed > 1.8 m/s will escape into an independent heliocentric orbit, while a particle ejected with a body-fixed speed < 1.0 m/s will usually return to the surface; final evolution for ejecta speeds between these limits is a function of initial location on the surface. For Toutatis, "energy-pumping" perturbations do not play as large a role as for an asteroid rotating about its largest moment of inertia. Thus it is relatively rare for an orbiting particle to be ejected from the Toutatis system due to repeated interactions with the asteroid's gravity field. This property enhances the asteroid's retention of low-velocity ejects.